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YIELD CHARACTERISTIC OF BIODIESEL DERIVED FROM USED VEGETABLE OIL METHYL ESTER (UVOME) BLENDED WITH DIESEL, IN THE PRESENCE OF SODIUM HYDROXIDE (NAOH) AND POTASSIUM HYDROXIDE (KOH) CATALYST, AS ALTERNATIVE FUEL FOR DIESEL ENGINES

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ABSTRACT

Used vegetable oil methyl ester (UVOME) was derived through transesterification process, by using used vegetable oil (UVO) and methanol in the presence of either sodium hydroxide (NaOH) or Potassium hydroxide (KOH) catalyst. The UVO, methanol and NaOH catalyst were mixed with various proportions, in mixing tank and heated up to 55-60^{o}C, at constant speed stirring for 4 hours and cool it for 12 hours, to retrieve the UVOME. To get the better yield of biodiesel, the various proportions of UVO, methanol and NaOH were taken for producing the biodiesel. Then, this yield is compared with the same proportions of UVO and methanol, in presence of the catalyst KOH. The yield of produced biodiesels of BN (Bio-diesel in presence of NaOH), BK (Bio-diesel in presence of KOH) were analyzed. The maximum yield (87%) of UVOME (BK) was derived through transesterification, in the presence of KOH catalyst was higher than the yield of UVOME (BN), which was derived by using NaOH catalyst. If the methanol and catalyst concentration were increased in transesterification process, the yield of BK and BN were also increased.

KEYWORDS: Used Vegetable Oil Methyl Ester, Catalyst, Sodium Hydroxide, Potassium Hydroxide & Biodiesel Yield

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Original Article

INTRODUCTION

Consumption of energy is increasing worldwide in various forms for a variety of purposes. The amount of consumption is directly proportional to a society's growth. Today developing countries are prospering through economic reforms and are becoming technologically advanced. Fuel is critical to any tactical plan for economic growth and national security. In developing countries like India, the fuel has implicit economic cost in the forms of budget deficits caused by imports of oil and ecological dreadful conditions caused by pollution. The imports statement on these items is around Rs.18000 crores and the intensification rate of diesel consumption is more than 15% per annum[1]. When it comes to world energy consumption which is drastically increased for last decade people still depends mostly on fossil fuels to fuel their vehicles, in spite of the environment problem that flow from burning coal oil and natural gas. So many research works are carried out in many nations like India to search an appropriate fuel source such as solar and the wind as the great alternatives which are neat copious and on the edge of mass production in a upcoming days that always seems around the corner yet eternally out of reach[2].

Nowadays, renewable energy sources of the world's supply, fossil fuels provide about 85%

technologically higher which have damped the cost of renewable power sources, but technology has also kept down the price using fossil fuels and some cases reduced their unsafe effects on the environment. It is estimated that by 2020, the world may be consuming the energy 15 times higher when compared to the usages of energy in 1980[3]. Possibly as much as many environmentalists, the oil companies are willing to find alternatives to fossil fuels, because they understand that over the next century they will see their supply diminishing. The objectives of the present work are to investigate the engine performance, combustion performance and emission performance of Used Vegetable Oil Methyl Ester (UVOME) which is derived through transesterification process by using the biodiesel processor. The two different catalysts are investigated to find the maximum yield of UVOME. The biodiesel and its blends are investigated and compared with diesel.

MATERIALS AND METHODS

Preparation of Biodiesel

As mentioned earlier, the type of biodiesel is retrieved through transesterification process. Transesterification is also known as alcoholisis. It is the reaction of fat or oil with an alcohol to form esters and glycerin. A catalyst is used to improve the reaction rate and yield. Among the alcohols, methanol and ethanol are used commercially because of their low cost and their physical and chemical advantages. They rapidly react with triglycerides, NaOH and KOH and are simply dissolved in them. To complete a transesterification process, 6:1 molar ratio of alcohol is needed[4]. Enzymes, alkalis or acids can catalyze the reaction that is lipases, KOH and sulphuric acid, respectively. Among these, alkali transesterification is faster and hence it is used commercially [5].

Neutralization Process

- Measure UVO and pour in to a reaction container.
- Three gm of NaOH or KOH (for 1 litre of UVO) is mixed with 40 ml distilled water.
- The combination is then added to the oil in the reaction container.
- The mixture is stirred well and kept for setting.
- The oil is then filtered from the colloids (soap) which settle at the bottom.

Table 1: Combinations of the Raw Material for BN/BK

Sl. No.	UVO (ml)	Methanol (ml)	NaOH/KOH (g)
C1	400	92	2
C2	400	88	2
C3	400	84	2
C4	400	80	2
C5	400	88	2.4
C6	400	88	2.2
C7	400	88	1.8
C8	400	88	1.6
C9	440	88	2
C10	420	88	2
C11	380	88	2
C12	360	88	2

TRANSESTERIFICATION PROCESS

First Stage

- Make a solution with the lye first- put 1 gram of lye in 1 liter of distilled water. Make a small batch of this as need it every time to make a batch of bio-diesel but only need a bit each time. Here is how to check the PH value of used vegetable oil (the titration process).
- Measure out 10 ml of the isopropyl alcohol and put it in a clean glass bowl or beaker.
- Add 1 ml of the used vegetable oil.
- Then add 1 ml of the mixed lye solution.
- Mix it very well and then test the PH of the mixture with PH test kit. It comes with a little piece of paper called litmus paper. It changes color as the PH changes.
- Just match the color with the chart provided in the kit. It is pretty a simple. The PH will be somewhere around the 6.5 mark.
- Remember to get the PH 6.5 of used vegetable oil to the PH of 8. Thus, mass of the lye should be increased.
- Add more lye solution to the test bowl or jar to get it there. Take lye dropper and only add 1 ml of the lye solution at a time. Keep track of how many ml of the lye solution you have added in total.
- When test mixture reaches about PH 8.5 stop for a minute. From this calculate and resulting how much lye needs to add to the 15 Liter mix.

Second Stage

It is necessary to ensure that the produced bio diesel is of a good quality for the diesel vehicle. Most agree that most problems in the vehicles are caused by bad fuel[6]. Washing bio-diesel has the effect of making it that much cleaner burning. Injectors and internal engine parts can get clogged up with these compounds which are used to make bio-diesel that some glycerin, methanol and Lye are left in the fuel if it is not water washed. All the above products that were added to make bio diesel are soluble in water. This means that if the Produced bio-diesel is added with water then the impurities can be removed. It sounds reasonable. On the other side of the bio diesel will end up having trace amounts of water in it which is bad for engine, thus the drying of the Produced bio diesel is necessary before the use and needs to filter the water with the help of water filter before the extraction of the bio-diesel from the washing Tank.

The reservoir tank is filled with UVO oil and is heated up to 50-600°C and it is reached the mixing tank through the pipe. The reaction is carried out in the mixing tank where the UVO, methanol and the catalyst NaOH are mixed and stirred for 3-4 hours and let the mixture for 12 hours. After that the glycerin is separated from the mixture. Then the methyl esters are pumped to the collecting tank.

Procedure to Wash the Produced Bio-diesel

- Put entire 15-liter biodiesel in the washing drum, being careful not to put any seen glycerin in it. Add 5 liter of water and stir gently with a broom or other stick.
- Do not stir vigorously or will have a mess of soap on hands. Just let the mixture settle overnight and drain the

water from the bottom drain, as it is heavier than the bio-diesel which will float. Repeat the process 3 times until the water comes out clear with a PH of nearly 7.

The same procedure is followed for all the combinations of UVO, methanol, NaOH or KOH which are given in Table 1.

Results of the Yield of UVOME

Figure 1 shows the comparison of the yield of UVOME (%) by using two different catalysts (NaOH and KOH) by varying methanol, Figure 2 shows the comparison of the yield of UVOME (%) by using two different catalysts (NaOH and KOH) by varying UVO, and the yield of UVOME (%) is compared by using two different catalysts (NaOH and KOH) by varying catalyst concentration as shown in Figure 3. The Figure 4 to 6 clearly shows that, the yield of UVOME (BK) is derived through transesterification, by using KOH catalyst is higher than the yield of UVOME (BN) which is derived by using NaOH catalyst.

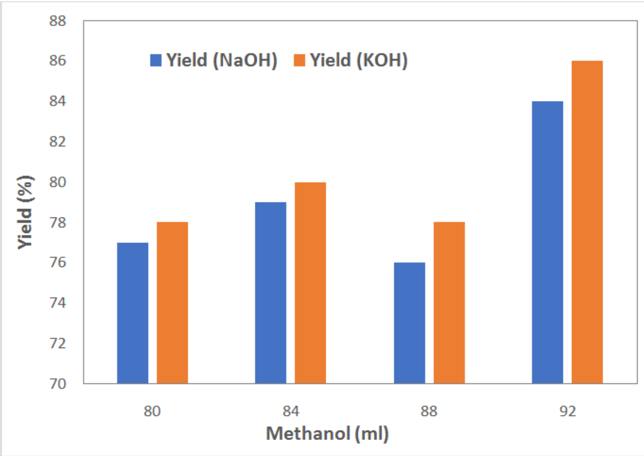

Figure 1: Yield of UVOME (%) with Methanol (ml)

It is observed that when the methanol concentration is increased in transesterification process, the yield of BK and BN are also increased [7]. The yield is higher, when the catalyst concentration is increased; however, it is lower when the UVO concentration is increased. Compared to the yield of BN, the maximum yield of BK is obtained 87% which is increased by 2.4 % than BN.

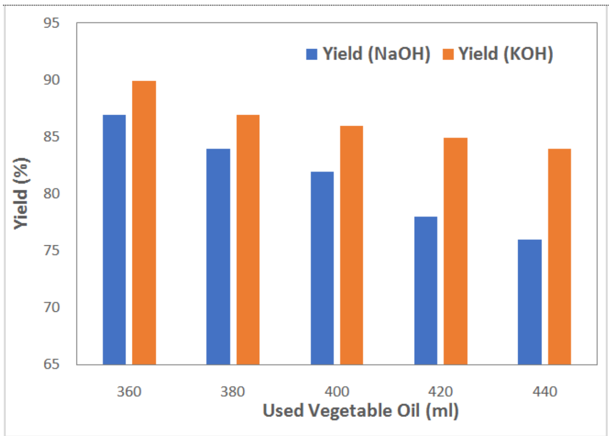

Figure 2: Yield of UVOME (%) with Used Vegetable Oil (ml)

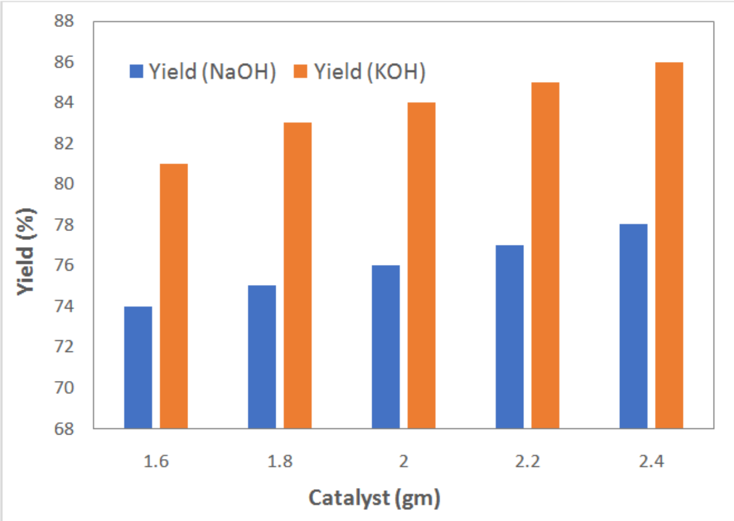

Figure 3: Yield of UVOME (%) with Catalyst (gm)

If the UVO is increased, the yield of BK and BN are reduced and also the yield of is BN is reduced by 2% than the yield of BK. When the concentration of catalyst is increased in the transesterification process, the yield of BN and BK are also increased [8]. The yield of BK is increased by 8% than the yield of BN. From these results it is observed that this emulsification can be improved reducing shaking intensity, during washing and separation of biodiesel from glycerol. In spite of better yield, using NaOH causes more emulsion than KOH and makes it difficult to separate biodiesel from glycerin. Due to this reason, KOH has been concluded as a better catalyst than NaOH, to retrieve the maximum yield [9].

Results of Used Vegetable Oil Methyl Ester (UVOME) Using Catalyst KOH (BK)

Brake Thermal Efficiency (BTE)

Table 2 shows that brake thermal efficiency (BTE) of UVOME (BK) and its blends is lower compared to that of diesel. At rated load the BTE of BK is lower than that of diesel**.** The variations of brake thermal efficiency suggested an inventiveness of the output produced by the CI engine with respect to energy supplied in the form of fuel. BTE is increased and it is higher for diesel compared to BK and its blends. Compared to diesel, BK and its blends such as B20K, B40K, B60K, B80K, and B100K (BK) have a smaller ignition delay; combustion is initiated much before TDC is reached. This increases compression work and more heat loss and thus reduces the brake thermal efficiency of the engine [10]. The minimum BTE of 28.56% is obtained for B100K due to the lower calorific value.

Brake Specific Fuel Consumption (BSFC)

The result for the variation in the brake specific fuel consumption (BSFC) for rated power output is presented in the Table 2. The BSFC values at 100% load conditions are 0.2852 kg/kW-h for diesel, 0.2998 kg/kW-h for B-20K, 0.3101 kg/kW-h for B40K, 0.3154 kg/kW-h for B60K, 0.3254 kg/kW-h for B80K and 0.3325kg/kW-h for B100K. BSFC value is found to be higher, when the engine is fueled with B100K. This may be due to the low energy content and high specific gravity of B100K when compared to diesel [11-13].

Exhaust Gas Temperature (EGT)

Table 2 shows the variation of exhaust gas temperature with BK and its blends and that are compared with diesel. This may be due to the burning of more fuel at rated loads and hence EGT is increased [14-16]. The exhaust gas

temperature for diesel 324°C, for B20K 371°C, for B40K 377°C, for B60K 380°C, for B80K 382°C and for B100K 394°C at 100% load condition. It is found to be that the exhaust temperature of bio diesel blend of B100K is higher than that of diesel and other bio diesel blends such as B20K, B40K, B60K and B80K. This may be due to the increased oxygen content of the bio diesel (BK) and its blends [17,18]. The combustion is increased and hence it may increase the exhaust gas temperature.

Table 2: Performance Values at Rated Output of the Tested Engine

Fuel Used	BSFC (kg/kWh)	BTE (%)	EGT (°C)
Diesel	0.2852	30.03	324
B20K	0.2998	29.06	371
B40K	0.3101	28.97	377
B60K	0.3154	28.84	380
B80K	0.3254	28.58	382
B100K	0.3325	28.56	394

CONCLUSIONS

The bio-diesel could be produced from used vegetable oil. The maximum yield of 87% was obtained for UVOME (BK), which was derived through transesterification in the presence of KOH catalyst was higher than the yield of UVOME (BN) which was derived by using NaOH catalyst. If, the methanol and catalyst concentration were increased in transesterification process, the yields of BK and BN were also increased. Brake thermal efficiency (BTE) of UVOME and its blends were lower compared to that of diesel. At rated load, the value of brake thermal efficiency of BK, BK blends were lower than that of diesel. Brake specific fuel consumption (BSFC) was increased BK and its blends because of their lower calorific value than that of diesel. It was also found that, the exhaust gas temperature (EGT) was increased with load, because of burning more fuel at higher loads and hence EGT was increased. It was also observed that the exhaust gas temperature of BK and its blends were higher than that of diesel. The maximum EGT of 394°C was obtained, when the B100K fuel was tested at full load condition. It was concluded that, used vegetable oil methyl esters (bio-diesels BN and BK) and their blends could be directly used in diesel engine without any engine modifications. Compared to all fuels, the B20 blends give reasonably acceptable values almost closer to diesel.

REFERENCES

1. *Talebian-Kiakalaieh A, Amin NAS, Mazaheri H. A review on novel processes of biodiesel production from waste cooking oil. Appl Energy 2013;104:683–710.*

2. *Sassykova L, Nalibayeva A, Aubakirov Y. Preparation and Study of Catalysts on Metal blocks for Neutralization of Exhaust Gases of the Stationary Diesel Generator. Orient J Chem 2017;33:1941–1908.*

3. *Yaakob Z, Mohammad M, Alherbawi M, Alam Z, Sopian K. Overview of the production of biodiesel from Waste cooking oil. Renew Sustain Energy Rev 2013;18:184–93.*

4. *Dr. J V Murugalal Jeyan & Akhila Rupesh, Experimental Investigations on the Performance and Exhaust Emissions of a Diesel Engine Using Jatropha Oil as a Fuel, International Journal of Bio-Technology and Research (IJBTR), Volume 5, Issue 4, July - August 2015, pp. 27-36*

5. *Baiseitov DA, Tulepov MI, Sassykova LR, Kudaibergenov KK, Mansurov ZA. The sorbents for collection of oil and petroleum of the phytogenesis. Int J Chem Sci 2015;13:1027–1033.*

6. Sassykova L, Gil'Mundinov, Shamil, Nalibayeva, Arailym, Bogdanova I. Catalytic systems on metal block carriers for neutralization of exhaust gases of motor transport. Rev Roum Chim 2017;62:107–114.

7. Sendilvelan S, Bhaskar K. Comparative performance studies on DI diesel engine with neem de-oiled cake and Jatropha methyl ester diesel blends. World J Eng 2017;14:348–352.

8. Sendilvelan S, Bhaskar K. Aluminium phosphate supported copper phosphate catalytic converter to reduce nitrous oxides and particulate matter from engine emission. Orient J Chem 2017;33:2111–117.

9. Abdullah NH, Hasan SH, Yusoff NRM. Biodiesel Production Based on Waste Cooking Oil (WCO). Int J Mater Sci Eng 2013:94–99.

10. S. Narasimha Kumar, Comparative Study of Performance, Combustion and Exhaust Emissions Analysis of Linseed Oil Based Biodiesel in a Ceramic Coated Diesel Engine, International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), Volume 4, Issue 2, March - April 2014, pp. 75-98

11. Mohammadshirazi A, Akram A, Rafiee S, Bagheri Kalhor E. Energy and cost analyses of biodiesel production from waste cooking oil. Renew Sustain Energy Rev 2014;33:44–49.

12. Kagawa S, Takezono K, Suh S, Kudoh Y. Production possibility frontier analysis of biodiesel from waste cooking oil. Energy Policy 2013;55:362–368.

13. Ullah Z, Bustam MA, Man Z. Biodiesel production from waste cooking oil by acidic ionic liquid as a catalyst. Renew Energy 2015;77:521–526.

14. D. Srikanth, M.V.S. Murali Krishna & P. Usha Sri, Influence of Injection Timing on Performance Parameters and Combustion Characteristics of High Grade Semi Adiabatic Diesel Engine with Cotton Seed Biodiesel, International Journal of Automobile Engineering Research and Development (IJAuERD), Volume 6, Issue 2, March - April 2016, pp. 1-14

15. Hossain ABMS, Boyce AN. Biodiesel production from waste sunflower cooking oil as an environmental recycling process and renewable energy. Bulg J Agric Sci 2009;15:312–7.

16. Murali Manohar R, Prabhahar M, Sendilvelan S. Experimental investigation of combustion and emission characteristics of engine is fueled with diesel and UVOME blends of B20K and B80K. Eur J Sci Res 2012;76(3), 327-334.

17. Sendilvelan S, Jeyachandran K, Bhaskar K. Experimental investigation of emission control from spart-ignition engine using electrically heated catalyst. SAE Tech. Paps. 2001-01-1845.

18. Zhang Y, Dubé M., McLean D., Kates M. Biodiesel production from waste cooking oil: 2. Economic assessment and sensitivity analysis. Bioresour Technol 2003;90:229–240.

19. Bilgin A, Gülüm M, Koyuncuoglu İ, Nac E, Cakmak A. Determination of Transesterification Reaction Parameters Giving the Lowest Viscosity Waste Cooking Oil Biodiesel. Procedia - Soc Behav Sci 2015;195:2492–2500.

20. Panadare DC, Rathod VK. Applications of Waste Cooking Oil Other Than Biodiesel A Review. Iran J Chem Eng 2015; 12:55–76.

21. Enweremadu CC, Mbarawa MM. Technical aspects of production and analysis of biodiesel from used cooking oil-A review. Renew Sustain Energy Rev 2009;13:2205–2224.